Exposure Assessment and Air Toxics

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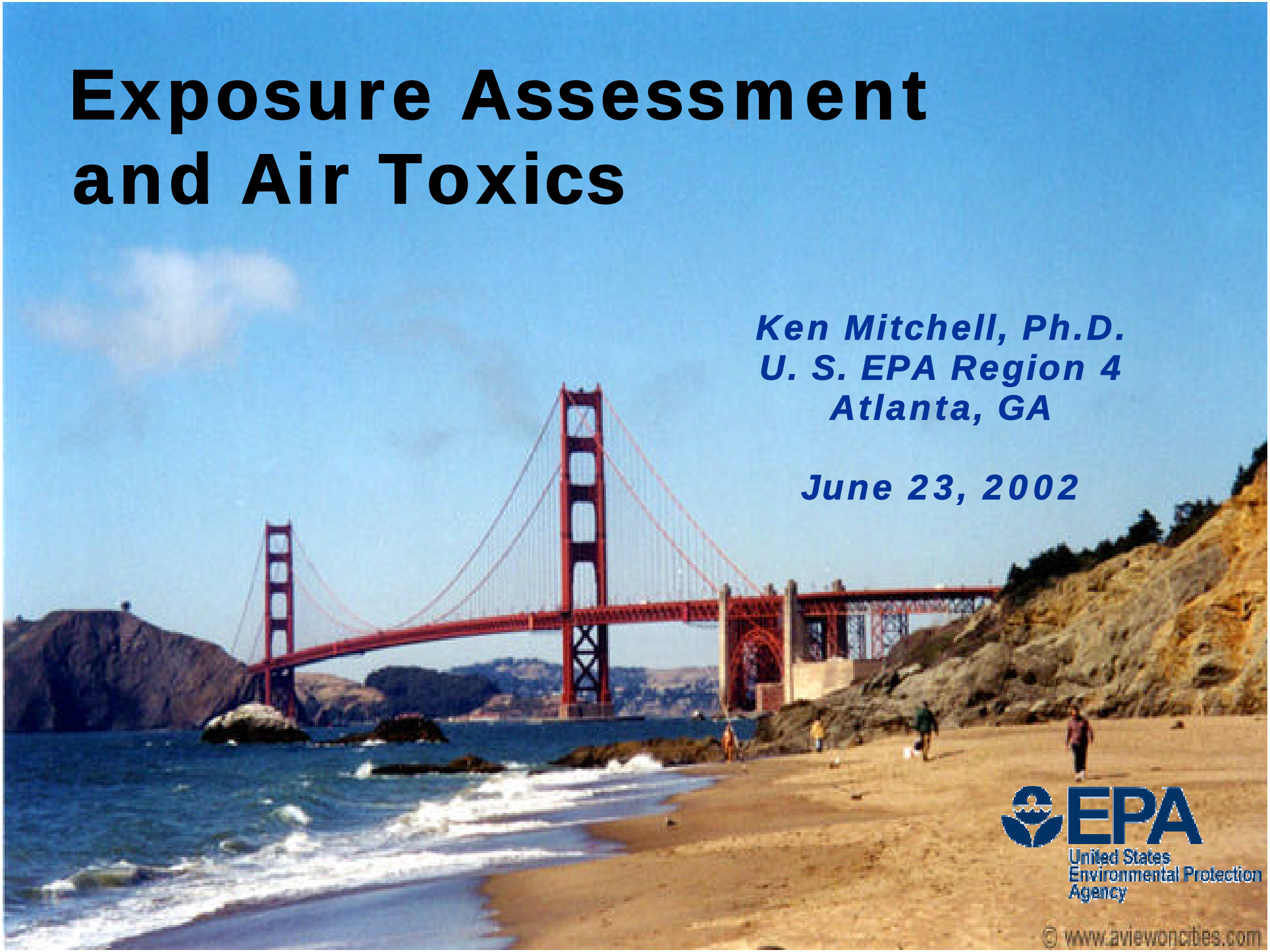
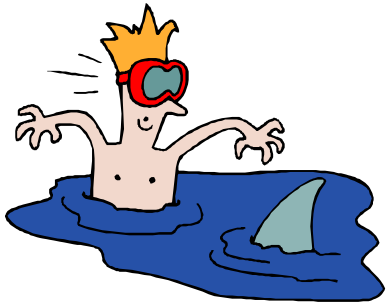


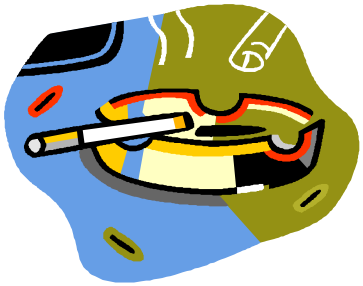

The mission of the U.S. Environmental Protection Agency is to protect human health and to safeguard the natural environment--air, water, and land--upon which life depends.

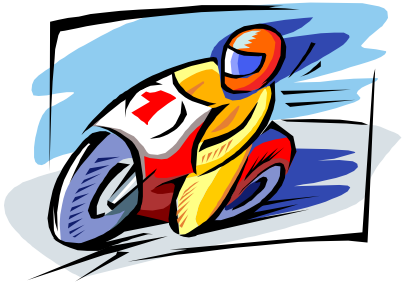
EPA's purpose is to ensure that:

All Americans are protected from significant risks to human health and the environment where they live, learn and work…

Lots of things are “risky!”



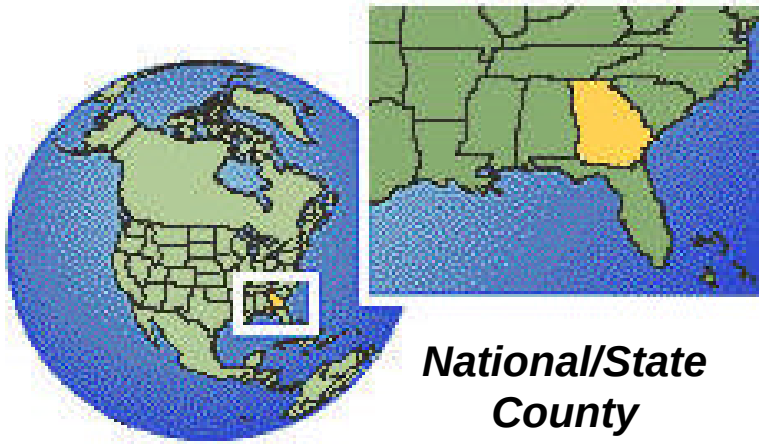




Risk from Exposure to Contaminated Air

Exposure at different scales

- What is our inhalation exposure to toxic chemicals of concern in our Region (at a “screening level of concern”)?
- What is our inhalation exposure to toxic chemicals of concern in our community (at a “high level of concern”)?



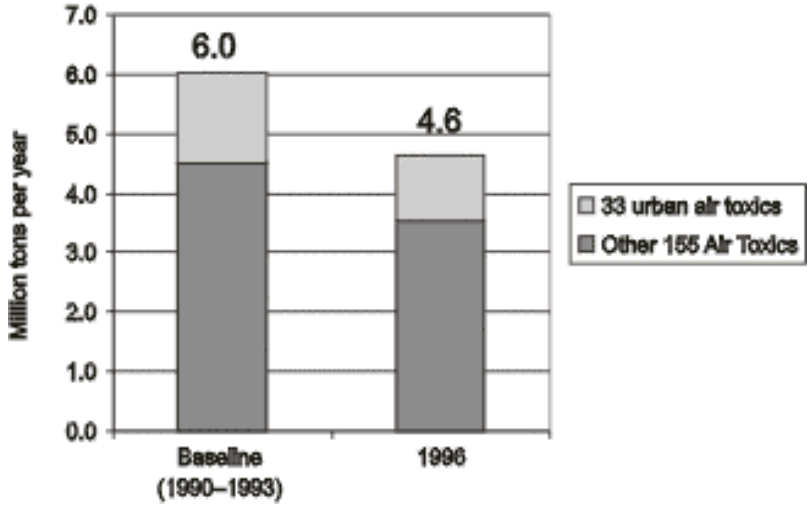
National/State County Level

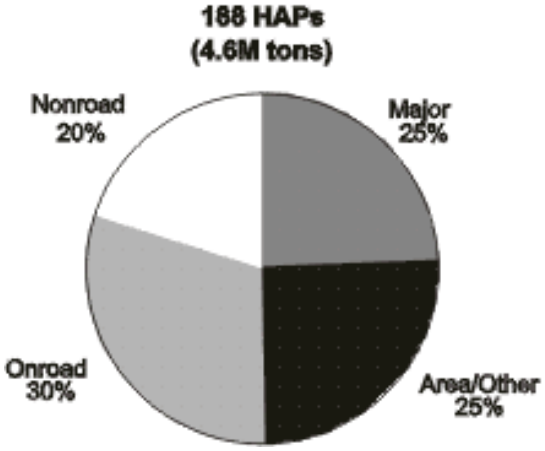
Community Level

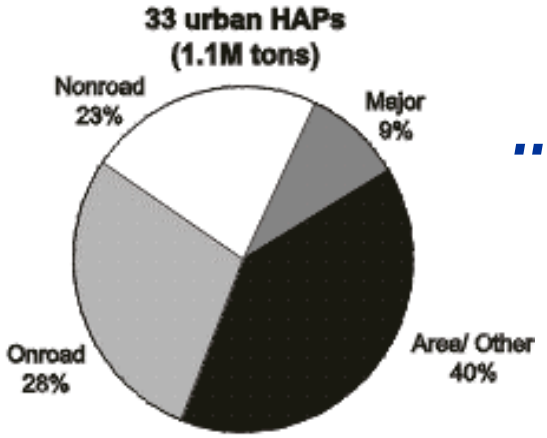
Air Toxics - Why are they potentially so risky?

- May cause cancer or other serious health effects in people or the environment
- May disperse locally to globally
- Potential to be persistent and/or bioaccumulate in the food chain
- Potential for multi-media exposure
- 188 compounds (hazardous air pollutants) listed in the Clean Air Act
  - 33 NATA priority chemicals
  - 21 mobile source HAPs

Air Toxics Emissions are decreasing……



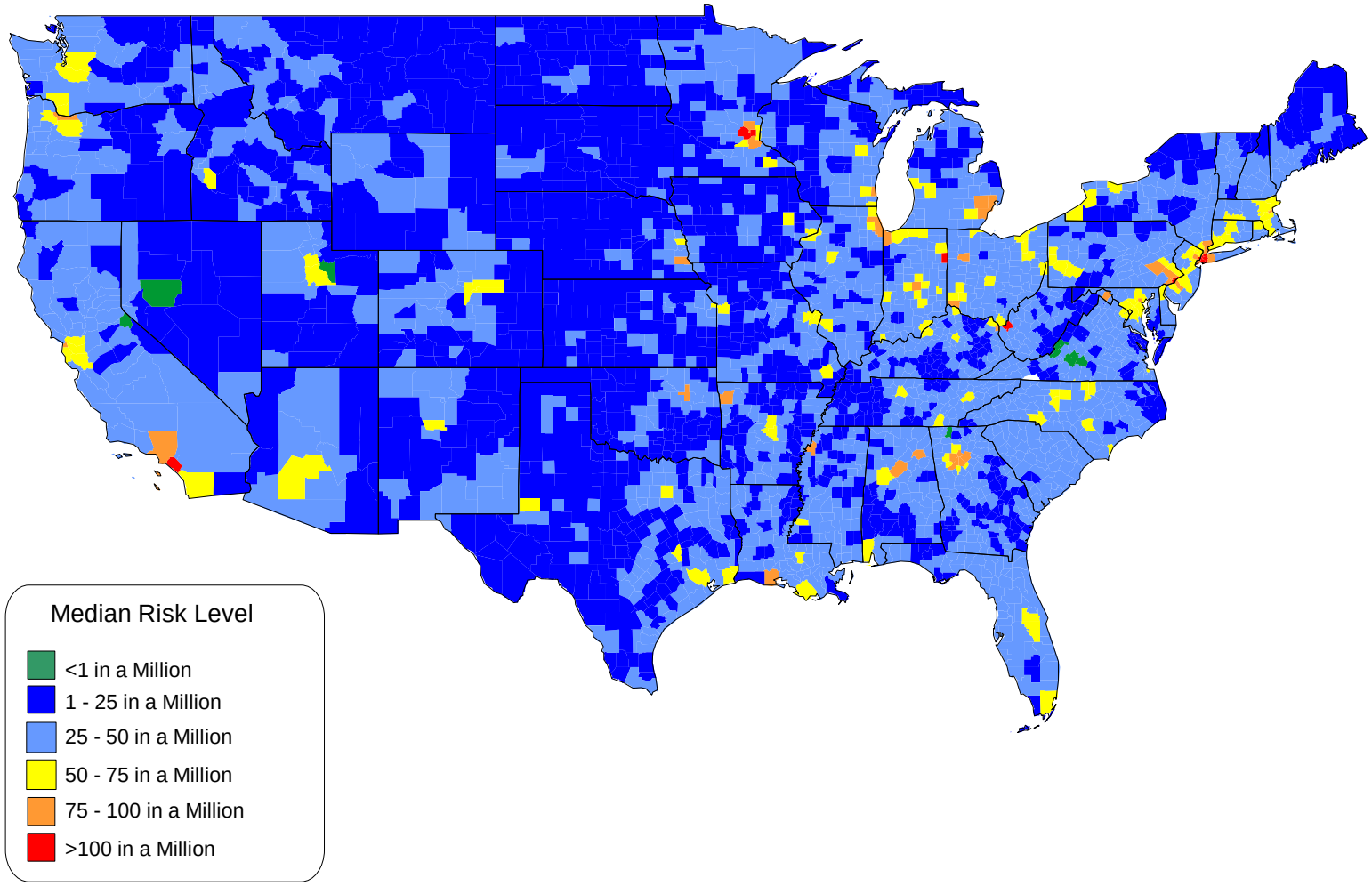




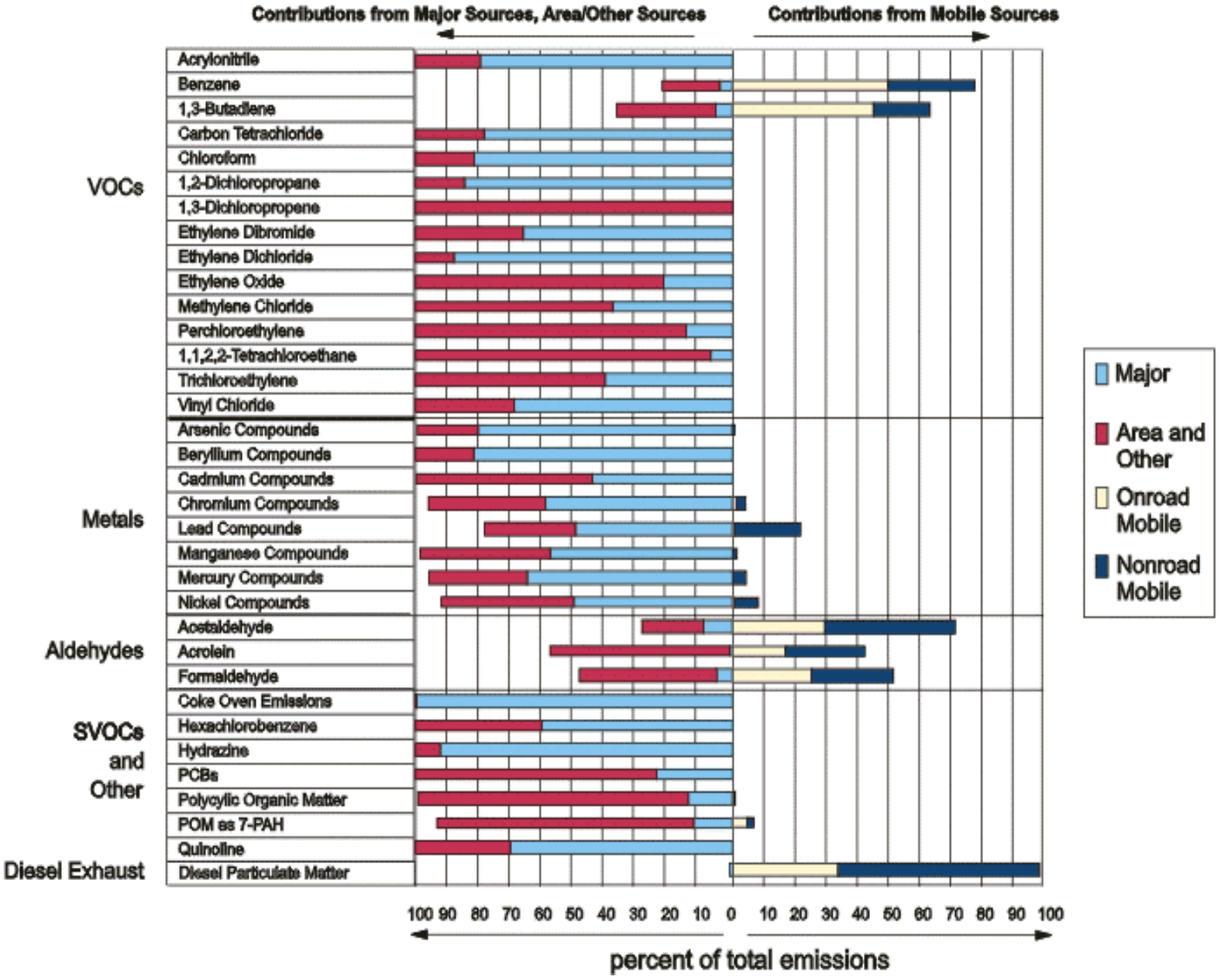
…but there is still work to do.

USEPA (2001) National Air Quality and Emissions Trends Report, 2999, OAQPS (EPA 454/r-01-004), March.

NATA - National Scale Assessment
Predicted County Level Carcinogenic Risk



Courtesy of Ted Palma/OAQPS.

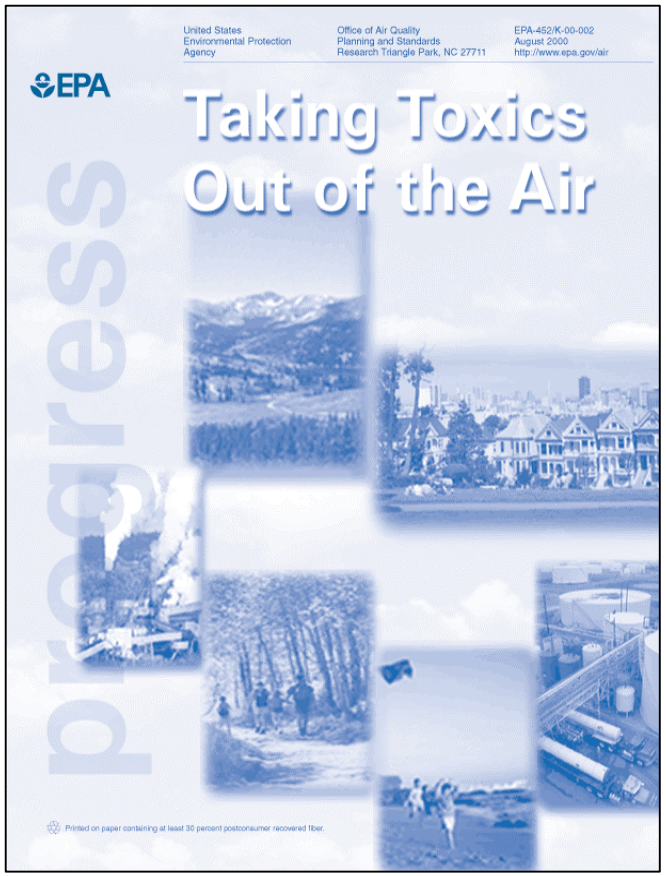


USEPA (2001) National Air Quality and Emissions Trends Report, 2999, OAQPS (EPA 454/r-01-004), March.

Don’t forget indoor air quality!

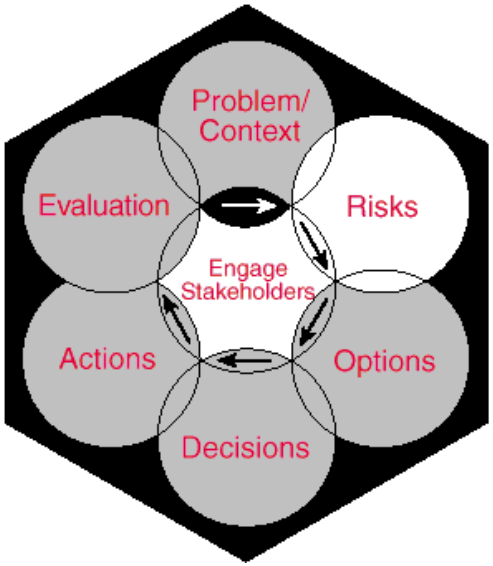
Indoor air can be many times more polluted than outdoor air and we usually spend more time indoors…

What are doing about air toxics?

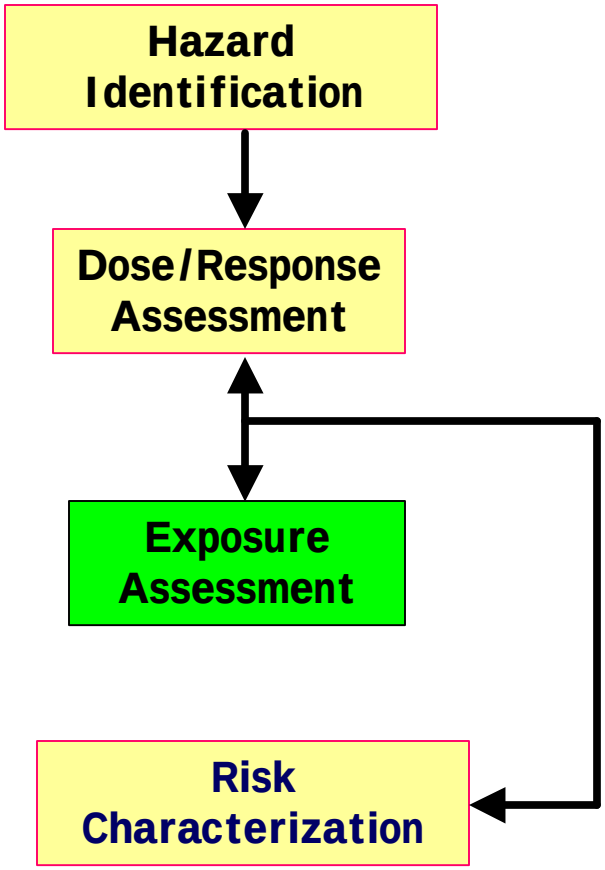


- Multiple programs and initiatives
  - Technology and risk-based standards (MACTS, residual risks)
  - Mobile source programs
  - Special Initiatives
    - Deposition studies
    - Urban Strategy
    - International transport

The Risk Assessment & Risk Management Paradigms



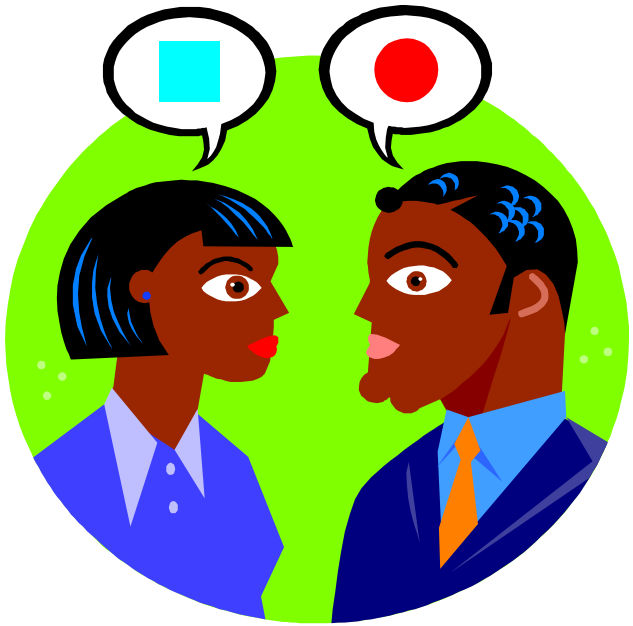
Risk Management Paradigm



Risk Assessment Paradigm

What is chemical "*exposure*?"

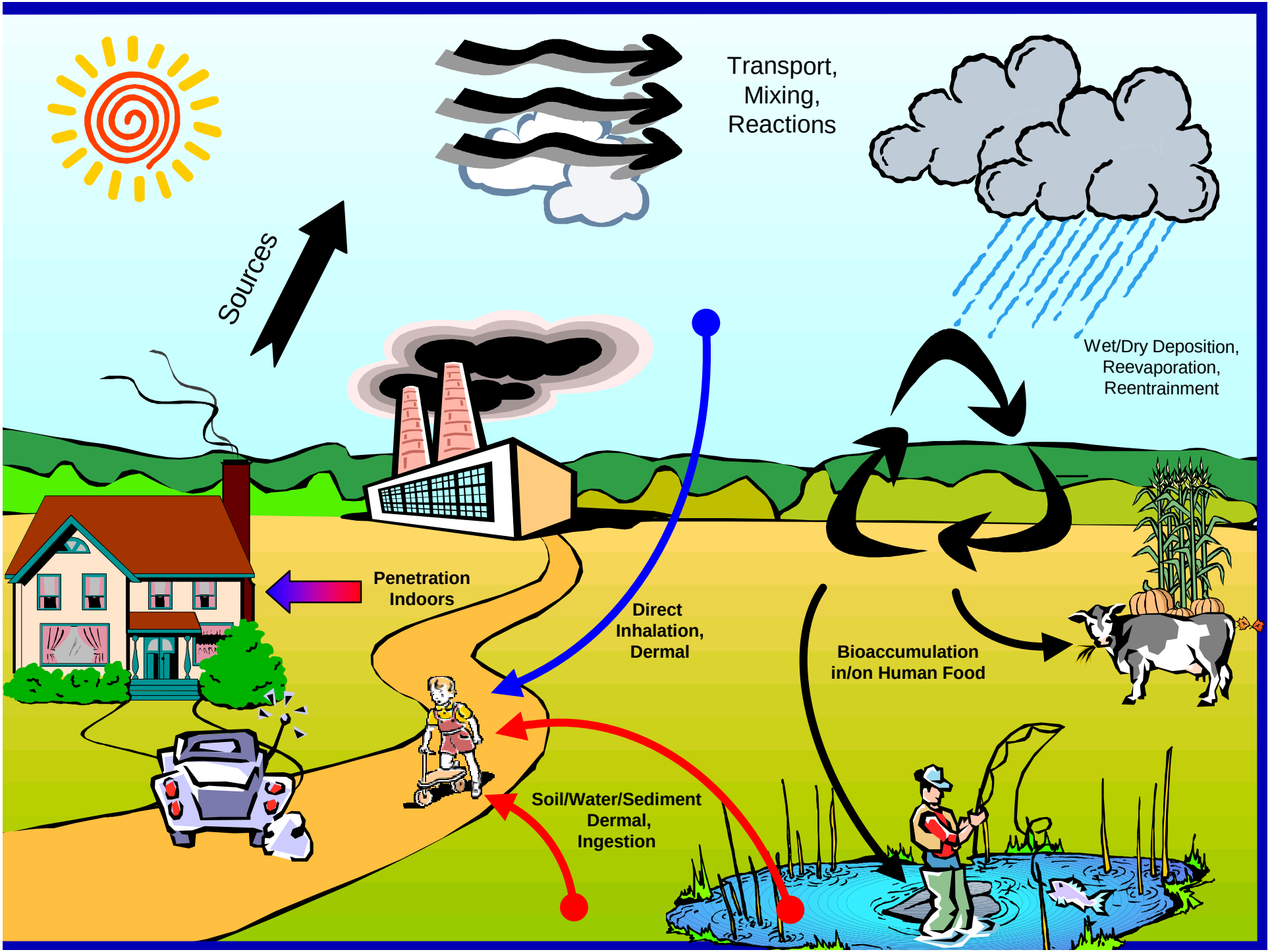
- The literature has various definitions for the point on or in the body where exposure takes place.
- *Human exposure* usually means contact with the chemical or agent, but this could mean contact with:
  - The visible exterior of the person (skin and openings into the body such as mouth and nostrils), or
  - The exchange boundaries where absorption takes place (skin, lung, gastrointestinal tract).



USEPA (1992), Guidelines for Exposure Assessment, 57 FR 22888.

EPA defines “exposure” as...

- Contact with the visible exterior of the person
  - Skin
  - Mouth
  - Nostrils
  - Punctures in the skin
- USEPA (1992), *Guidelines for Exposure Assessment*, 57 FR 22888.


Transport,
Mixing,
Reactions
Sources
Wet/Dry Deposition,
Reevaporation,
Reentrainment
Penetration
Indoors
Direct
Inhalation,
Dermal
Bioaccumulation
in/on Human Food
Soil/Water/Sediment
Dermal,
Ingestion

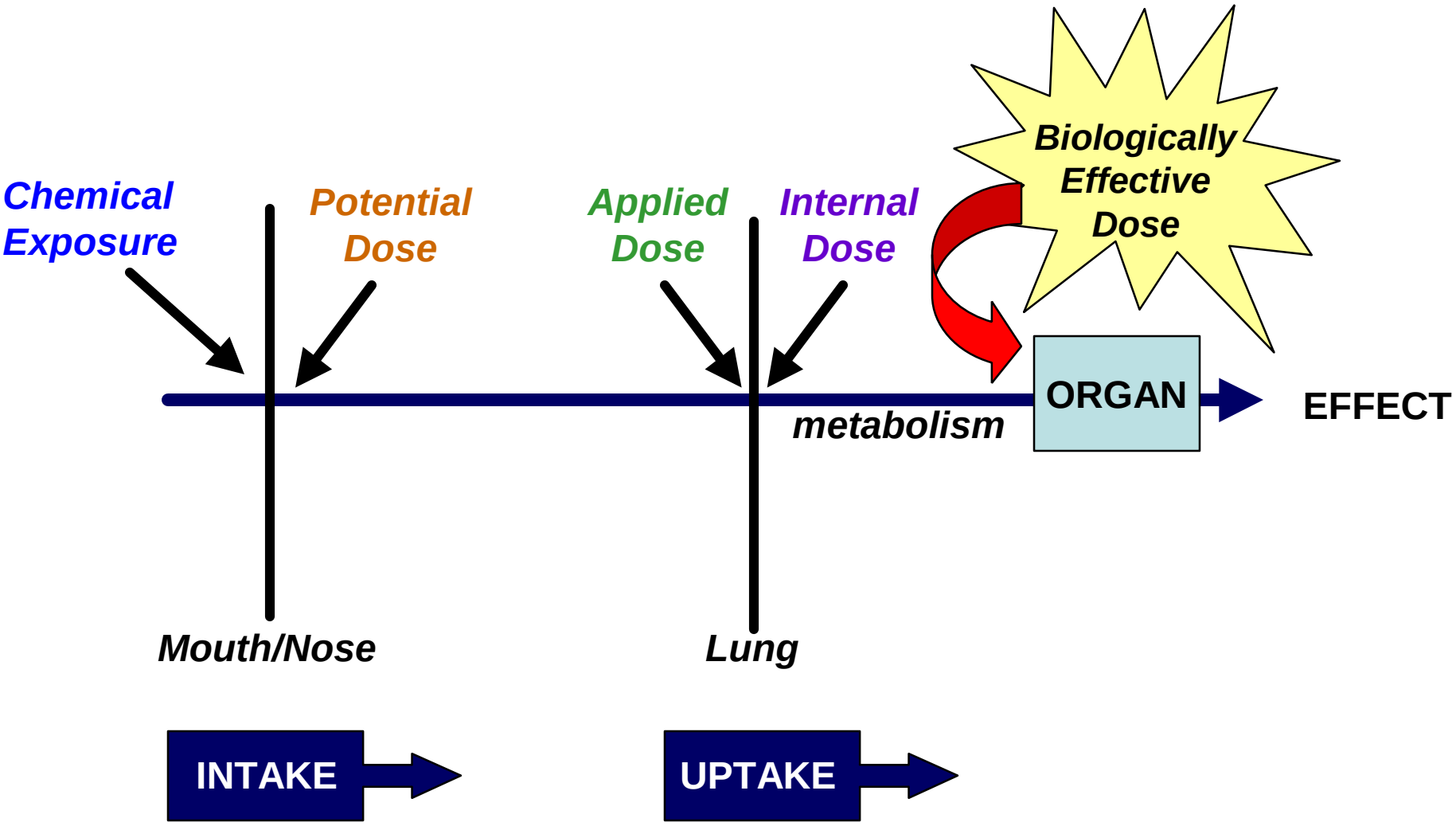
Intake and Uptake are Different!

- ***Intake*** - Physically moving a chemical through an opening in the boundary into the body (usually mouth or nose)
- ***Uptake*** - Absorption across the boundary (usually skin or eye)

Dose is different too!

- **Applied (or potential) dose**
  - Amount of a chemical at the absorption barrier (skin, lung, gastrointestinal tract) available for absorption.
- **Internal Dose**
  - The amount of a chemical that has been absorbed and is available for interaction with biologically significant receptors
- **Delivered Dose**
  - The amount transported to an individual organ, tissue, or fluid of interest
- **Biologically Effective Dose**
  - The amount that actually reaches cells, sites, or membranes where adverse effects occur

Example – Respiratory Route

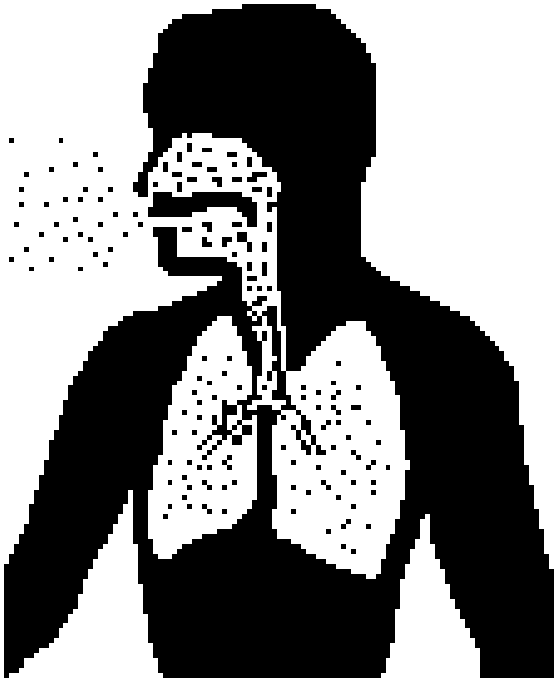


"Exposure Assessment"

- Quantitative or Qualitative assessment of contact which usually describes:
  - Intensity, frequency, duration of contact
  - Rates at which the chemical crosses the boundary
  - Route of exposure (inhalation, dermal, etc.)
  - Amount of chemical that crosses the boundary (potential dose)
  - Amount absorbed (absorbed dose)

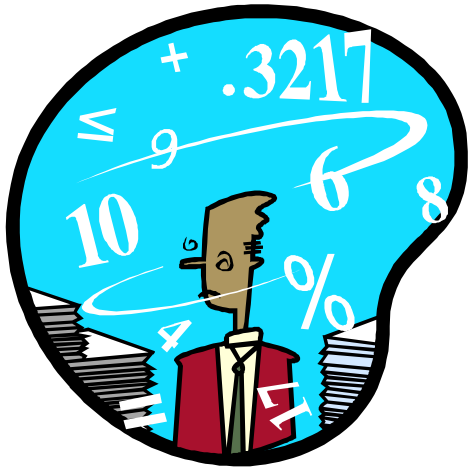
Exposure Assessment for Air Toxics

- Usually evaluate inhalation route of exposure
- "Indirect" routes of exposure are important for some chemicals that deposit on soil or water (e.g., dioxin, mercury)
  - Ingestion of Hg-laden fish
  - Eating lead-laden soils



Exposure Assessment

- **Characterize the exposure setting**
  - **Physical environment <u>including the scale of the study area</u>**
  - **Potentially exposed populations**
- **Identify exposure pathways**
  - **Exposure point**
  - **Exposure route**
- **Quantify exposure**
  - **Exposure concentration**
  - **Intake variables**
- **You must have a complete exposure pathway for there to be a risk**

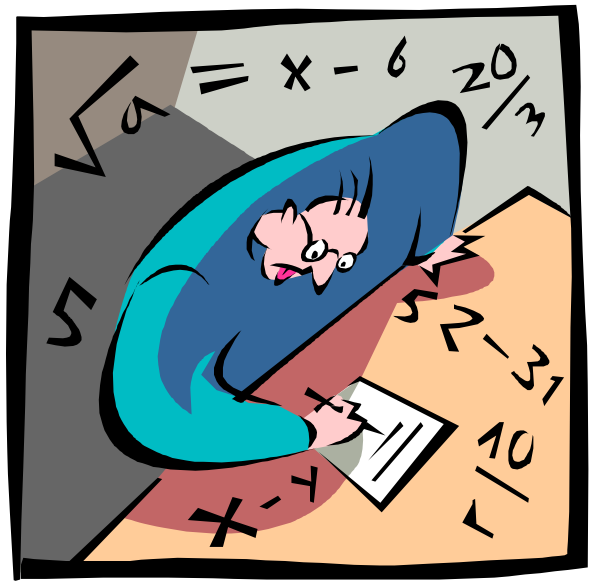


How do we estimate "exposure" & risk?

Risk =

Intake x (Toxicity) =

$$\frac{(C)(CR)(EF)(ED)}{(BW)(AT)} \times (Toxicity)$$



Where: C is concentration, CR is contact rate, EF is exposure frequency, ED is exposure duration, BW is body weight, AT is averaging time, and "Toxicity" is a factor that describes the toxic potential (dose/response) of a chemical

For inhalation, this usually solves to….

Risk = C/IUR *(for carcinogens)*

Hazard = C/RfC *(for noncarcinogens)*

Where: IUR is inhalation unit risk; and

RfC is reference concentration

****(Tox values are usually from IRIS)*

→ *WE WANT "C"* ←

How do we determine C…?

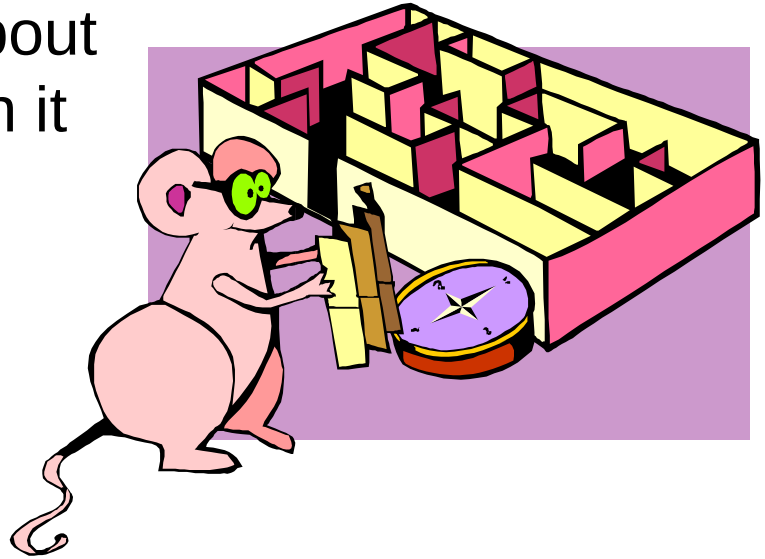
- Chronic Exposure
  - Low level exposure over an extended period of time
- Usually C is developed to be representative of long term concentration (e.g., annual average)
  - Modeling (ISC3, CalPuff, Aermod, etc.)
  - Monitoring (1 in 6 day ambient samples for a year, personal monitoring, etc.)
- C can reflect activity patterns
  - HAPEM4, APEX

How do we determine C…?

- Acute Exposure
  - High level exposure over a short period of time
- C can also reflect short term exposures (15 minutes, 1h, 24h, 2 weeks)
- Chronic and Acute effects are often different

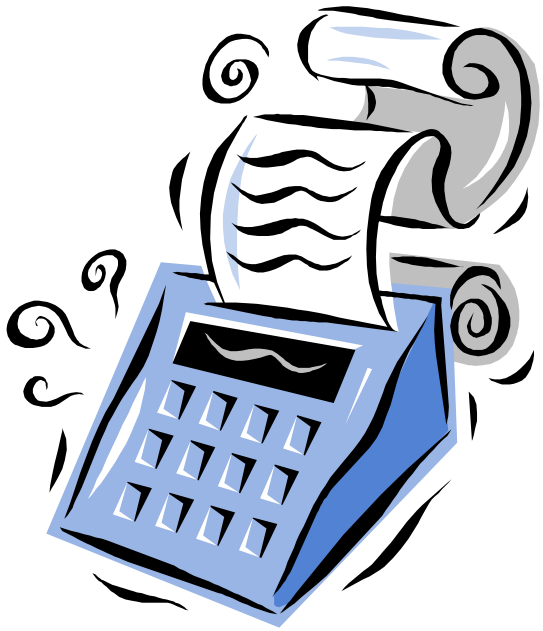
C and measures of toxicity are interrelated

- Our underlying assumptions about C should match the underlying assumptions about the toxicity factor we match it with when calculating risk
  - Cancer
  - Chronic noncancer
  - Acute noncancer
  - Reproductive & developmental

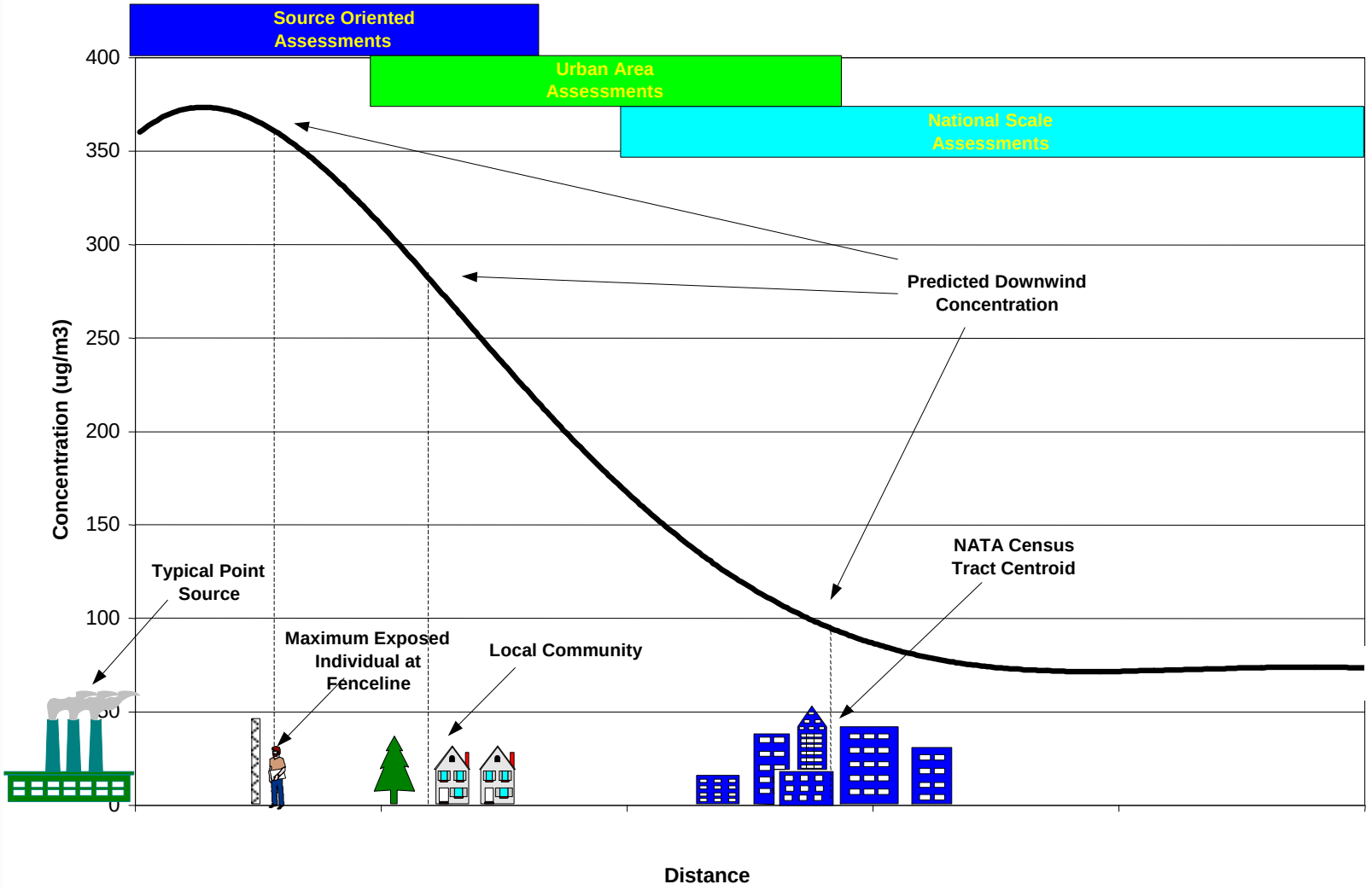


Cumulative exposure is important...

- There are usually multiple sources in an impacted area…transport into an airshed may also be important
- Source by source assessment may significantly underestimate risk
- Tools and guidance are being developed
  - RAIMI
  - *Framework for Cumulative Risk Assessment*



Exposure Assessment at Different Scales



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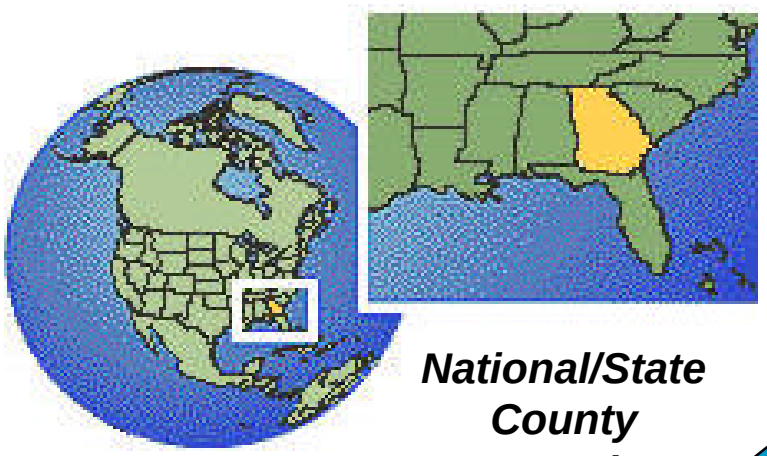
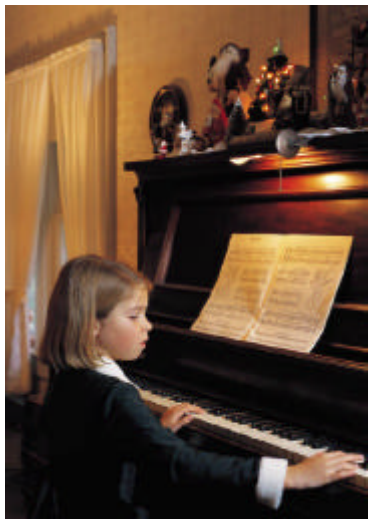


National/State County Level

Community Level

Neighborhood Level



Personal Level

Organ Level

Exposure Assessment at Different Scales

- Screening level of assessment on a large geographic scale
  - NATA ASPEN modeling
  - Limited national air toxics “trends” monitors
- Refined analysis at a smaller geographic scale
  - Personal monitoring, microenvironments
  - Intensive monitoring/modeling/emissions inventory at the community level
  - Assessment of activity patterns in a particular place
  - Pharmacokinetic models
- Assessment goals drive the data requirements

Exposure Assessment at Different Scales

- Screening level assessment at low geographic resolution usually provides lower certainty estimates of risks to receptors in specific communities (this is the “big picture”)
- Refined analysis at high geographic (or personal or biological) resolution usually provide higher certainty about risks to specific receptors in specific places
- “Certainty” at any scale depends on the tools and inputs used in the particular assessment

In summary…

- Exposure vs. exposure assessment
- Calculating “exposure” and risk
  - Modeling vs. Modeling
  - Chronic vs. Acute
  - Attention to toxic endpoints
- Scale is important
- Uncertainties exist at every point along the way